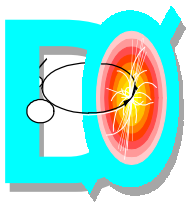
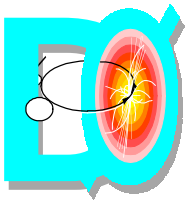


The Run 2 Dzero Muon System at the Fermilab Tevatron

Sharon Hagopian
Florida State University
Tallahassee, Florida
U.S.A.

for the DØ Collaboration

7th International Conference on
Advanced Technology and Particle Physics
Villa Olmo, Como, Italy, October 15-19, 2001



Outline

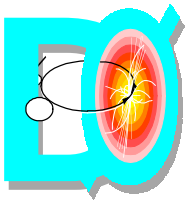
Upgrade Overview

Central Muon Detectors

Forward Muon Detectors

Readout and Triggering

Conclusions



Proton-antiproton collisions at the Tevataron

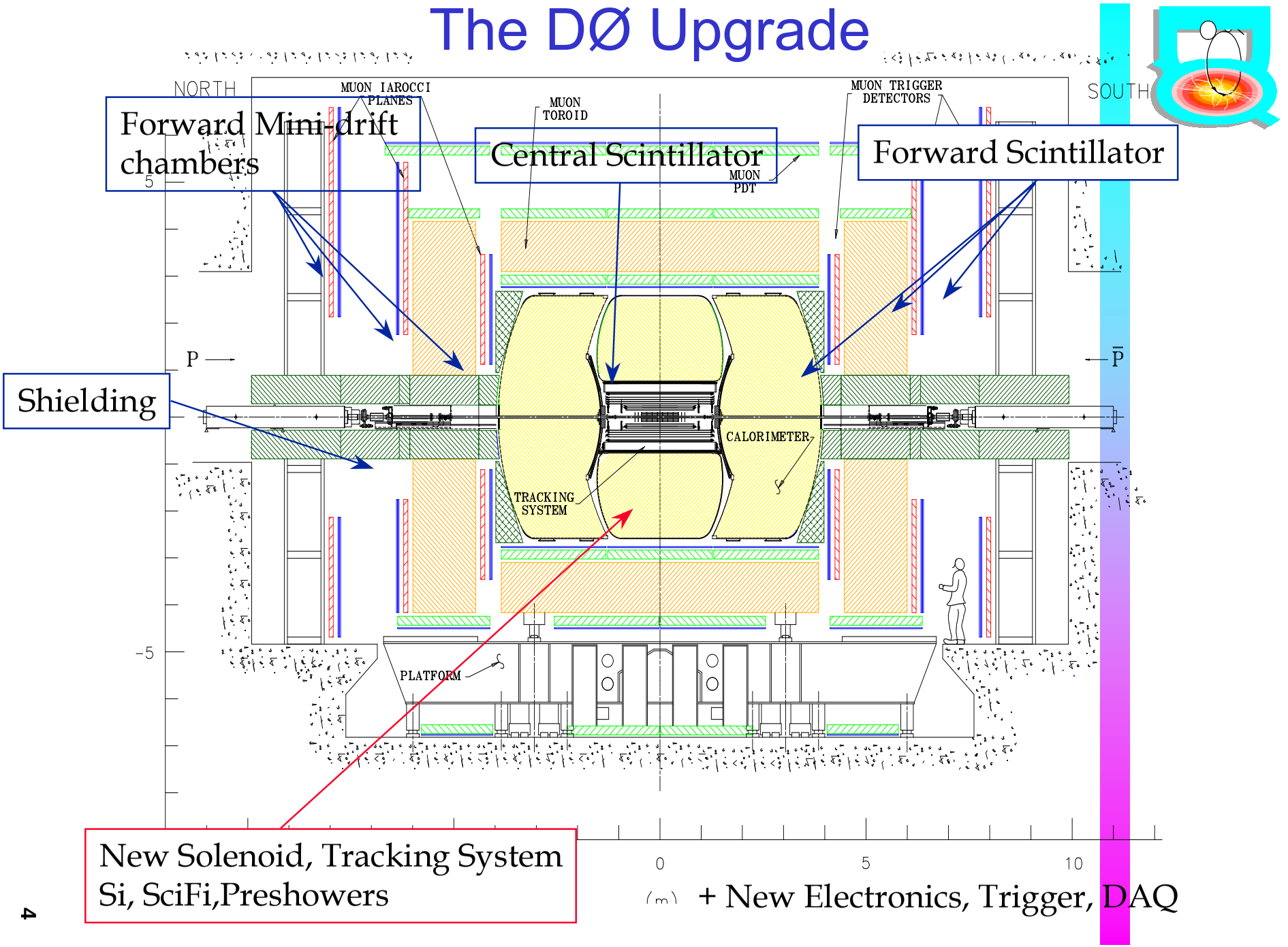
- **Upgrades for Run 2**

  1. **Increase Luminosity**
     - **Run I operated at 2×10^{31} cm^{-2} s^{-1}**
     - **Run II designed to achieve 5×10^{32} cm^{-2} s^{-1}**
  2. **Bunch spacing**
     - **Run I bunch spacing was 3.5 μs**
     - **Run II will begin with 396 ns, and eventually reach 132 ns**
  3. **Increase in CME from 1.8 TeV to 1.96 TeV**

- **Detector challenges**
  - **Large occupancies and event pile-up**
  - **radiation damage**

- **Start of Run II - March, 2001**

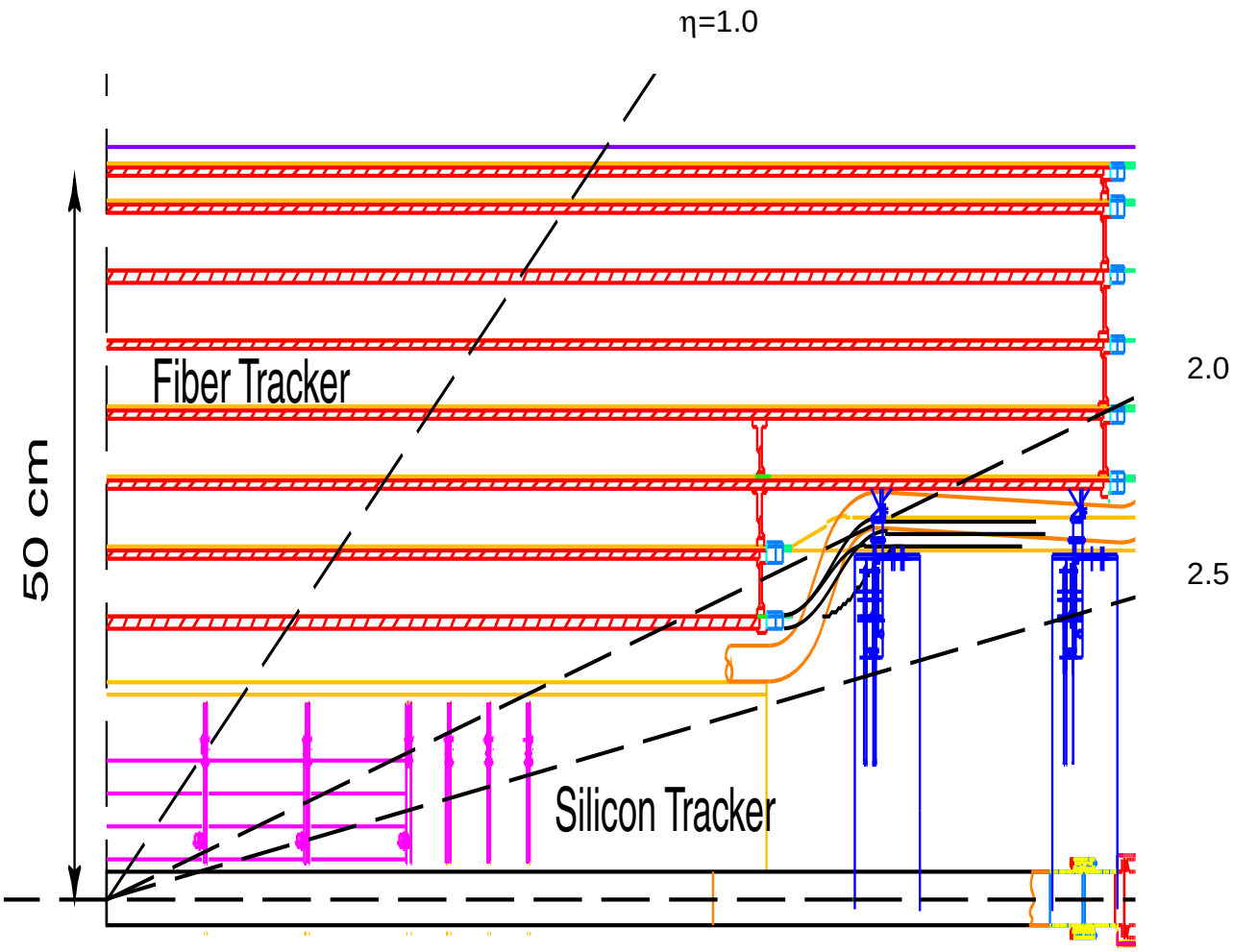
The DØ Upgrade



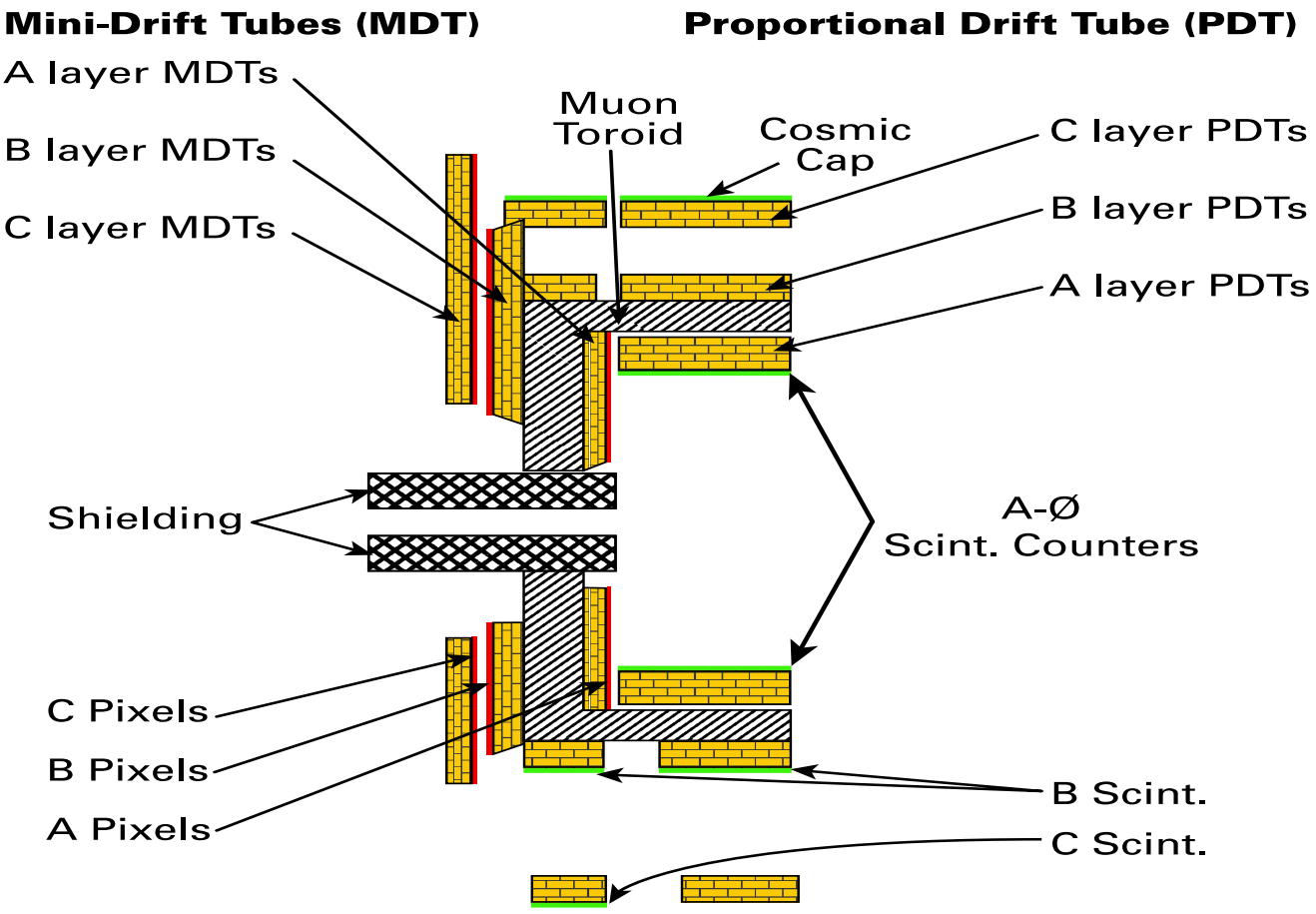
Central Fiber Tracker Features

- **Two Main Functions**
  - **1. With Silicon System**
    - Track reconstruction
    - Momentum measurement for $|\eta| < 1.7$
  - **2. Fast Level 1 Triggering**
    - Trigger on any charged particle with $p_t > 2$ GeV
    - Combining information from muon and preshower system: single μ, e triggers

Central Fiber Tracker



Run 2 DØ Muon System

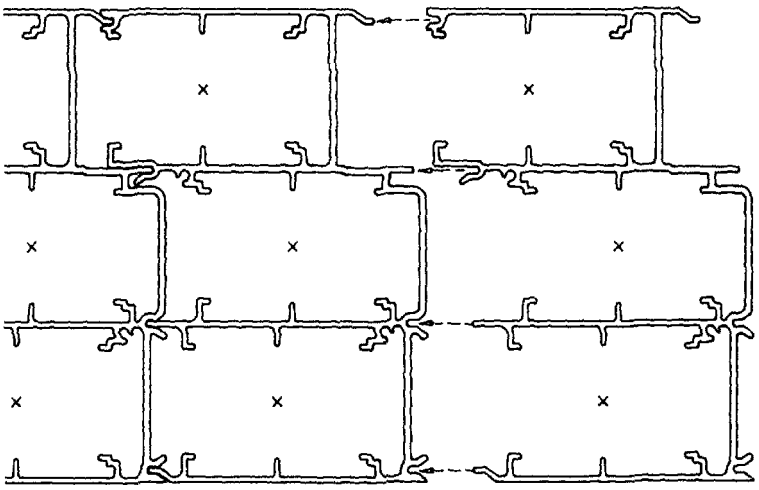


Wide Angle Muon System

Proportional Drift Tubes (PDTs)

built for Run I $|\eta| < 1.0$

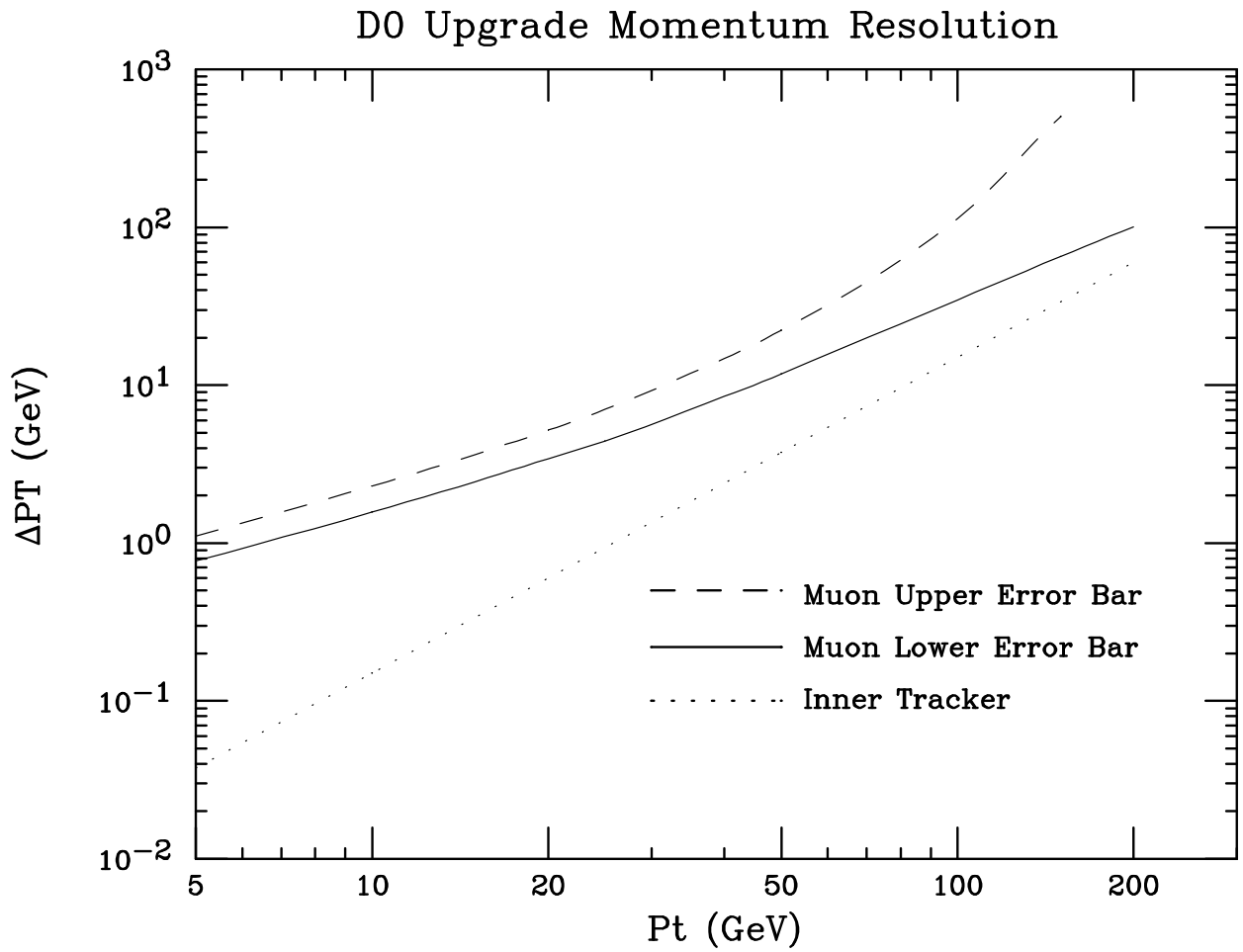
A layer – 18 modules (4 decks, 3 bottom)
toroid magnet – 2 T
B layer – 38 modules (each 3 decks)
C layer – 38 modules (each 3 decks)
typical module – 2.8 m x 5.6 m
cell size - 5 cm x 10 cm
rectangular aluminum tubes
drift distance resolution ~ 500 microns



Momentum Resolution

Ø WAMUS Momentum Resolution

- Ø inner tracker: ~ $\delta p_T = 0.0015 p_T^2$
- Ø WAMUS: $\sigma(1/p) = 0.18(p-2)/p^2 + 0.005$ (p in GeV/c)



Wide Angle Muon System

Cosmic Cap Scintillators

C layer – 240 counters

B layer (gap) – 16 counters

Cosmic Bottom Scintillators

B layer – 90 counters

C layer - counters 240

used for triggering and
to reject cosmic rays

A-ϕ Counters

A layer - 630 counters

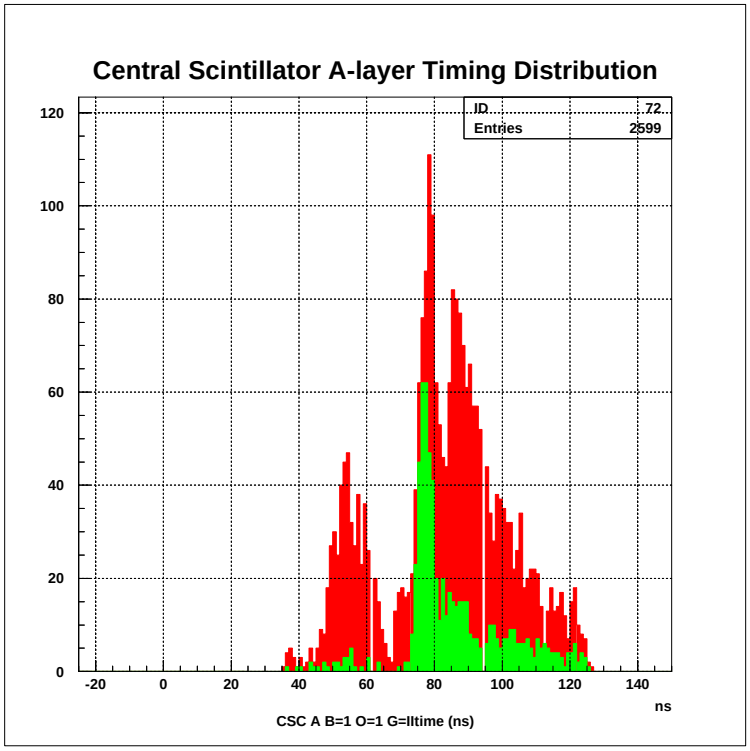
phi segmentation = 4.5 deg.

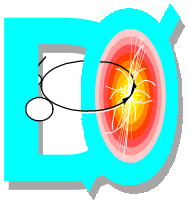
used for muon triggering,
reject out-of-time scattered particles,
identify low p_T muons

Scintillator Times

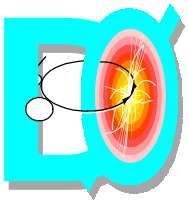
Red histogram – A layer times for all cen. muon trigger

Green histogram – A layer times for single cen. muon + 5 GeV jet trigger





PDTs and Scintillators



Forward Angle Muon System

Mini-drift Tubes - MDTs

Built by Joint Institute for Nuclear Research,Dubna

Assembled into octants at Fermilab

Cover: region $1.0 < |\eta| < 2.0$

Tubes have 8 cells, 1cm x 1cm cross section, made of aluminum extruded combs on plastic sleeves

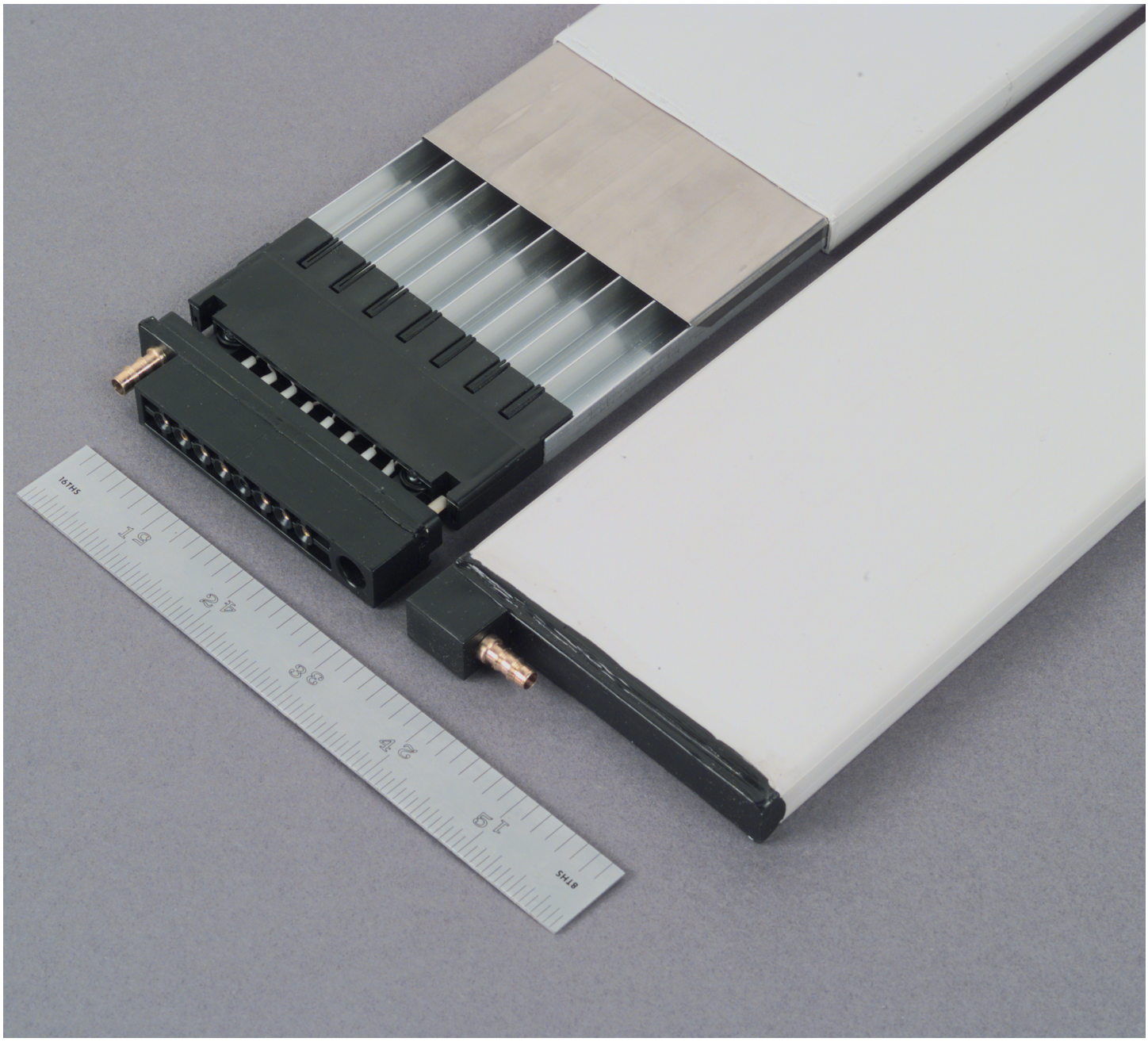
A layer, toroid, B layer, C layer

50,000 channels

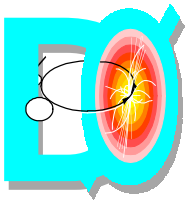
Coordinate resolution ~ .7 mm/layer

Momentum resolution ~20% for low p

MDT Module



MDT Octant



Forward Angle Muon System

Scintillator Pixels

Built by Institute for High Energy Physics, Protvino

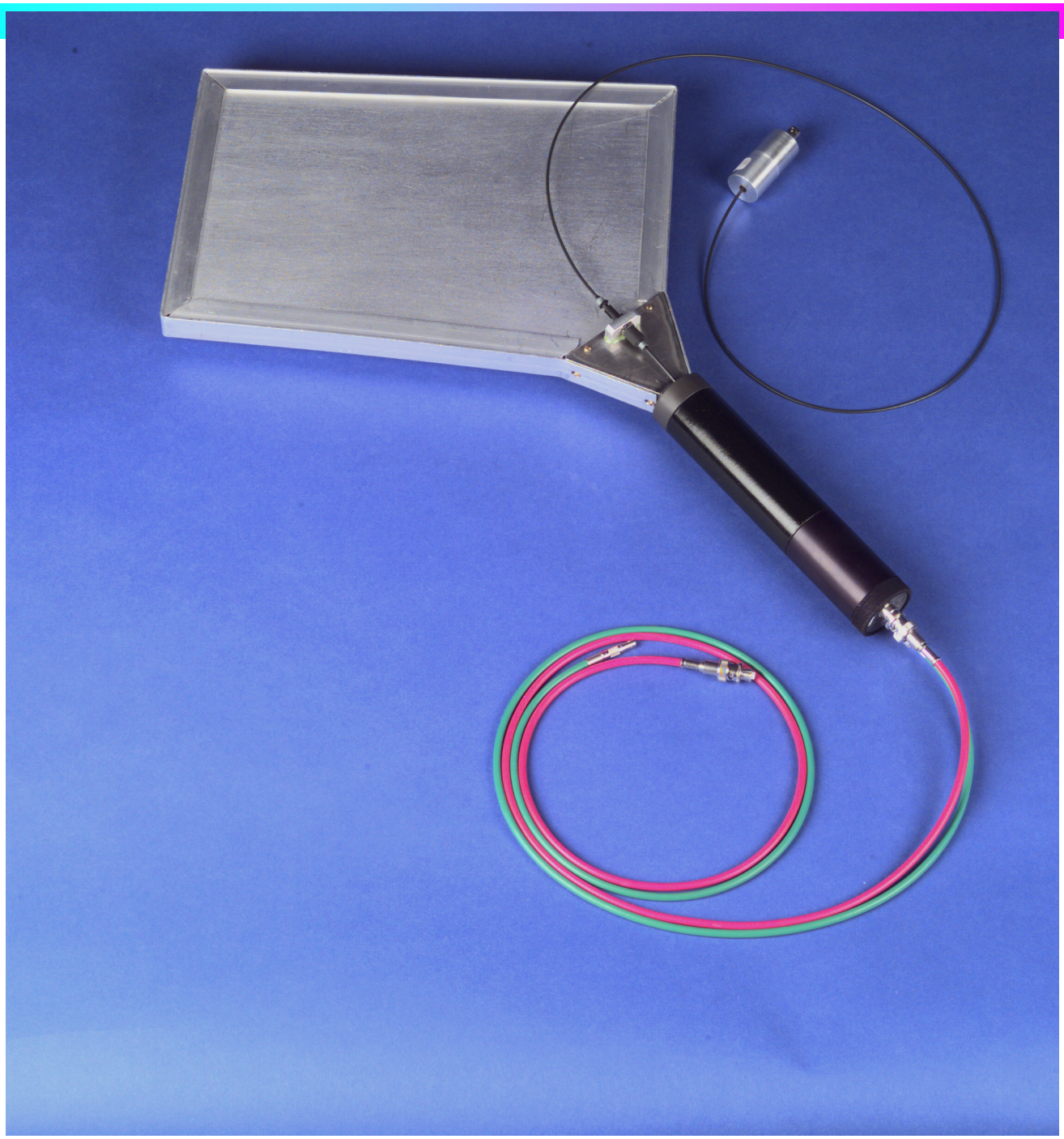
Assembled into octants at Fermilab,
96 counters/octant

phi segmentation - 4.5 deg matches CFT
eta segmentation - .12(.07)

Typical size - 20 cm x 30 cm

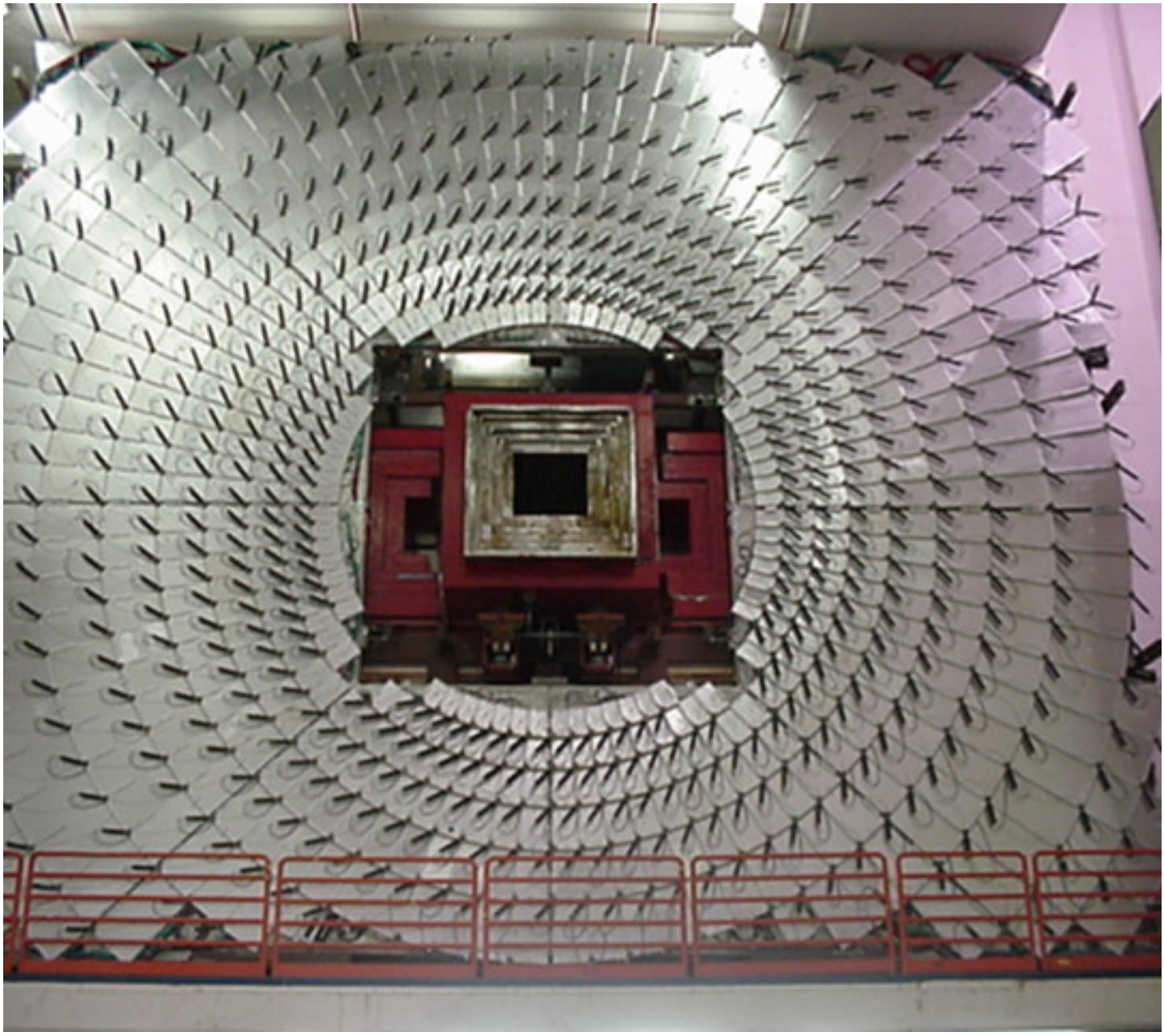
Radiation hard Bicron 404A scintillator
Kumarin WLS bars for light collection into PMTs

Scintillator Pixel



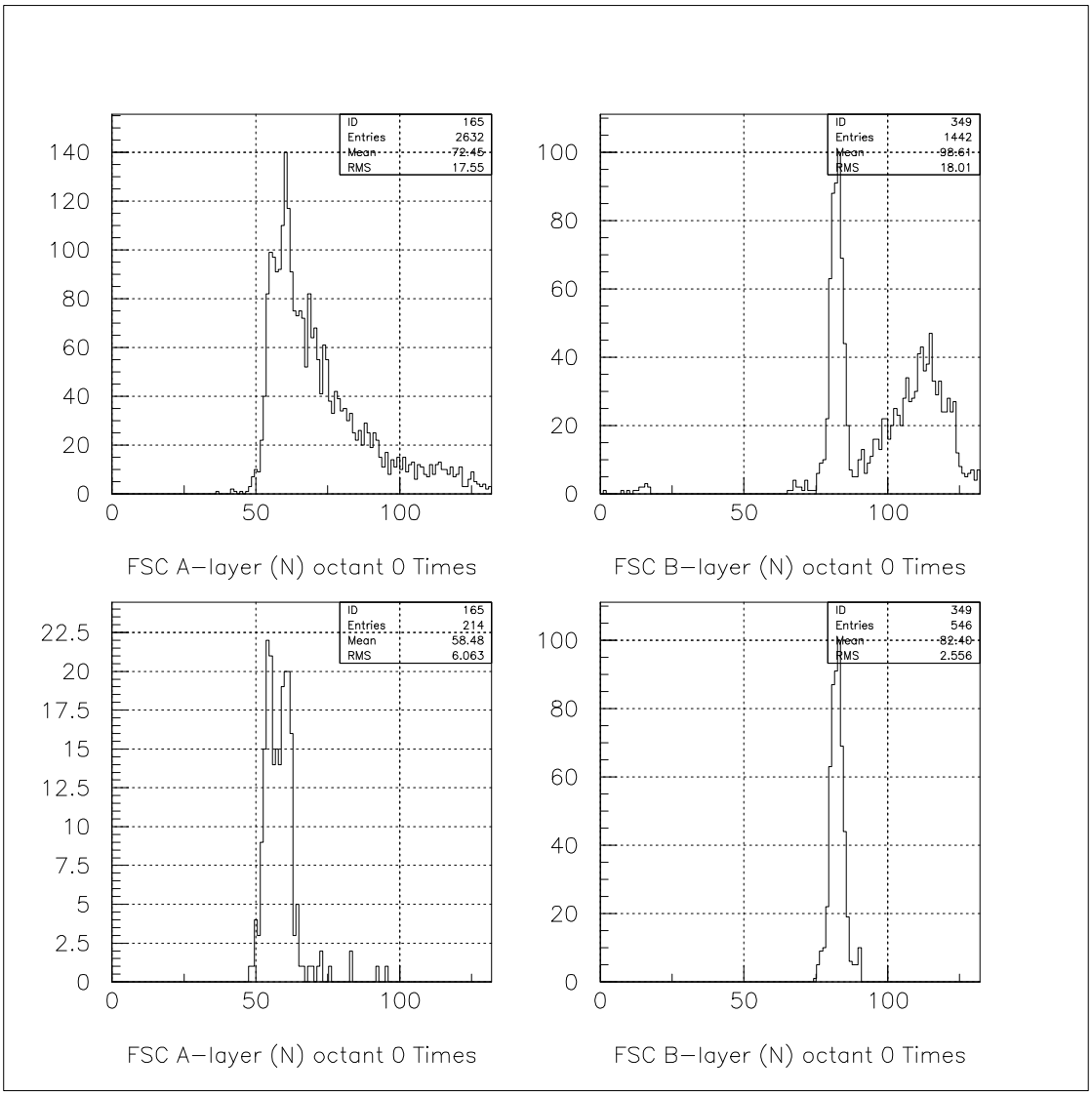
Scintillator Octant

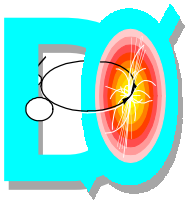
Forward Muon Scintillation Pixels



Pixels

- **Selection of muon hits in A layer by cutting on timing in B layer (single muon trigger)**





Digital Signal Processors

Purpose of the DSP

- Make muon segments from nearby hits in a single layer
- Buffer the L1 accepted data from the Front-end, while a Level 2 decision is pending.
- Re-format this data, if accepted by Level 2 and send it to the Level 3 trigger system.

Features of the DSP

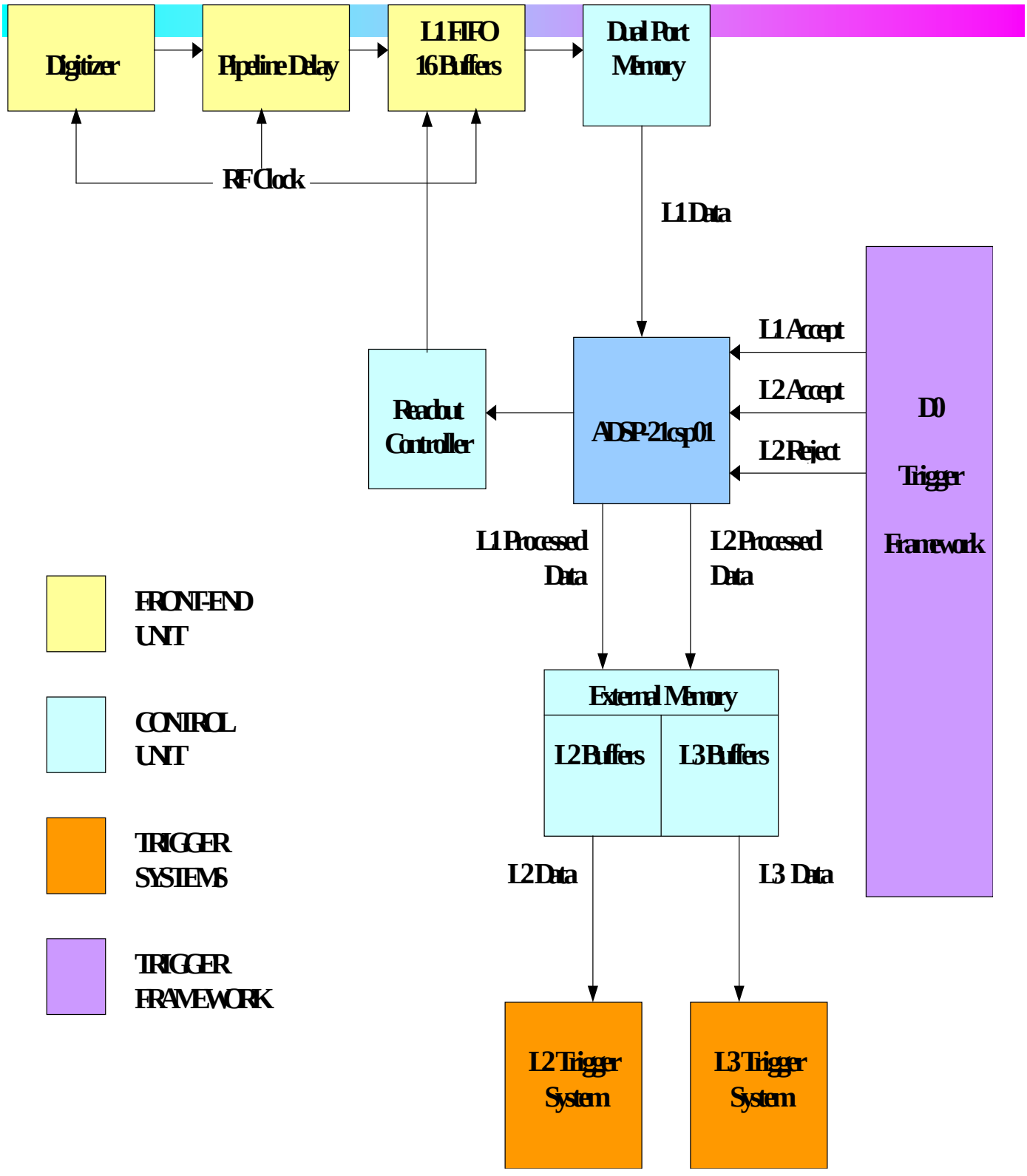
- High input/output bandwidth.
- Fast task switching.
- Code is Interrupt based, written in Assembly language and runs online.

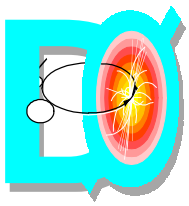
PTDs – 94 DSPs

MDTs – 24 DSPs

Pixels – 18 DSPs

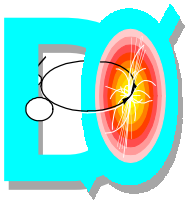
D0 Muon Buffering Scheme





Run 2a Trigger Systems

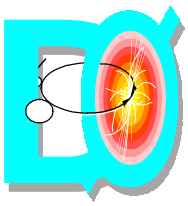
- **Level 1: a pipelined hardware stage**
  - muon, tracking and calorimetry information
  - uses Field Programmable Gate Arrays (FPGAs)
  - decision time – 4.2 μsec trigger rate: 10KHz
    - complete for central calorimeter
    - Complete for muon systems
    - work has begun for tracking and preshower systems
- **Level 2: a second hardware stage**
  - uses Dec Alphas
  - combines and refines Level 1 information with preprocessors for each subdetector
  - combines information in a global processor
  - max. decision time ~100 μsec
  - trigger rate: 1KHz
    - in the commissioning phase



Run 2a Trigger Systems (cont.)

Level 3: two stages

- custom-built data acquisition system
- a Linux farm of processors which
  does partial online event reconstruction
  and uses filters to accept or reject events
- decision time of 50 msec
- sustained trigger rate: 20Hz
  - currently running with some filters and rejecting events
  - half bandwidth is expect in a few months
  - full bandwidth by spring
- Output event size 250 Kbytes



Muon Triggers

Level 1

Uses: timing, hits, segments in A,B,C layers, octants in Cen, North, South

Current Triggers: single muon, muon + jet, dimuons

Future Triggers: muon +CFT, mixed leptons

Level 2

Muon Preprocessor: uses calibration, more precise timing information

muon candidates have timing, p_T, η, φ, quality

Global processor: combines muon, calorimeter, and central tracks

Level 3

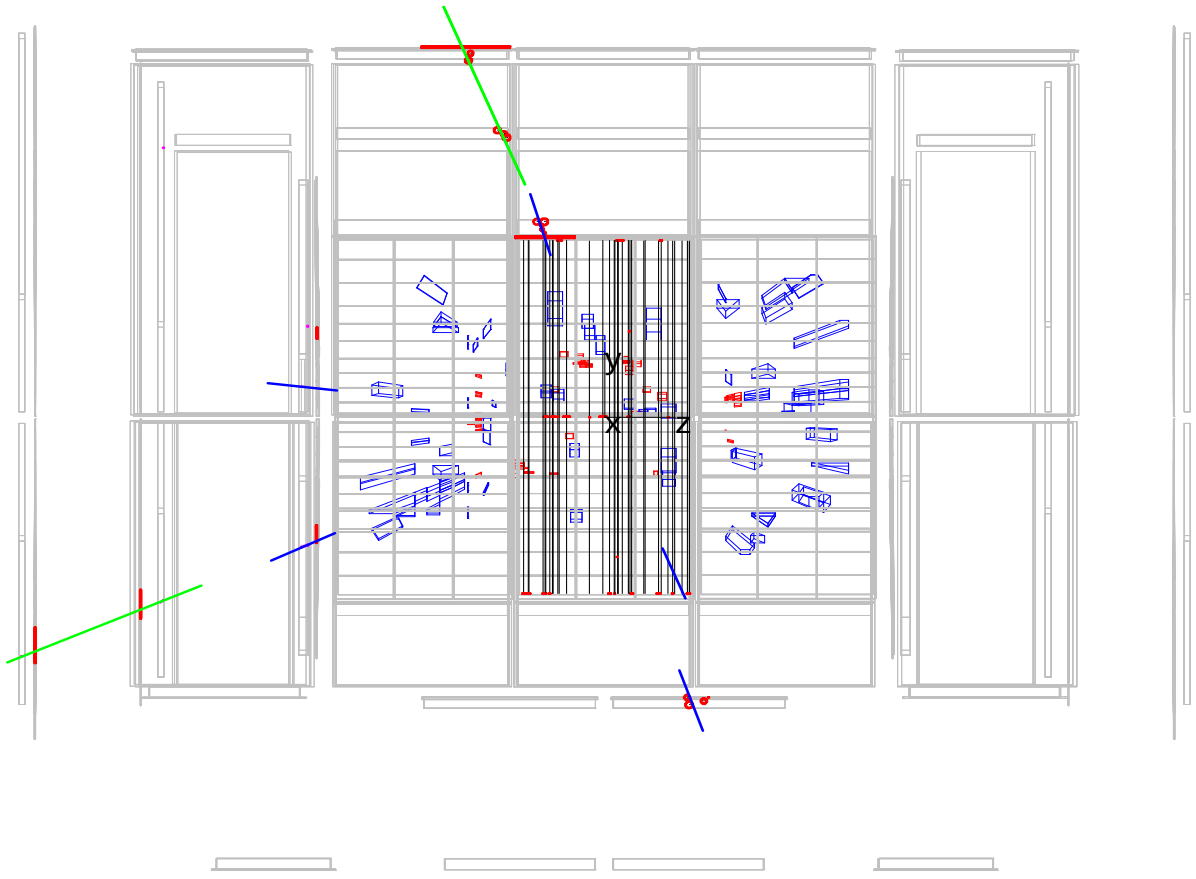
Uses: hits, segments, muon tracks

Matches: muons to central tracks, calorimeter information

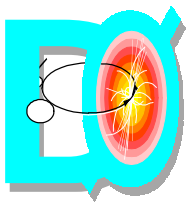
Accepts or rejects events for offline reconstruction

Z→μμ Candidate

Run 130080 Event 2862833 Mon Sep 10 15:39:35 2001



View 2, Side (Z-Y)



Physics with Muons

- **Electroweak - W/Z $\rightarrow\mu$**
- **Search for New Physics**
  - **SUSY particle searches**
    - **including trileptons**
    - **chargino/neutralinos**
    - **sleptons**
  - **Leptoquarks**
  - **W´, Z´ - heavy vector bosons**
  - **Massive stable particles**
- **Muon b-tagged jets**
  - **B physics**
  - **top – single top and pair prod.**
  - **higgs $\rightarrow$b $\underline{b}$**

Conclusions

Run 2 has started!!

- We've been taking muon physics triggers for calibration and commissioning.
- We should have a fully capable detector with stable running conditions by Winter.
- Look for first results at Moriond 2002, physics results by summer 2002
- A very exciting time ahead ……